Can Dynamic Goods Explain Asset Returns?

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Abstract

Recent evidence indicates the new goods bias in the Consumer Price Index is large and cyclical (Broda and Weinstein, 2010). Because standard theory prices assets by the discounted value of *real* payoffs, these findings have implications for asset pricing. In this paper, I use the growth of *dynamic* goods—goods subject to more innovation—as a proxy for the growth of new goods, and include this as an additional risk factor in the CCAPM. Because of the greater volatility and procyclical nature of dynamic goods, the empirical performance of the model improves along several dimensions: It can explain most of the cross-sectional variation in returns across the 25 Fama-French portfolios, and predicts a time-varying equity premium of around two percent.

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Introduction

Consumption-based asset pricing models value assets by how well they perform when consumption is low. Yet although new goods effectively lower the price of consumption, existing empirical work in asset pricing deflates consumption using standard price indices. By failing to properly account for new goods, these indices exhibit a substantial upward bias (Broda and Weinstein, 2010). Especially relevant for asset pricing, this bias also varies over the business cycle, rising in booms and falling in recessions. Thus by making consumption more volatile and cyclical, new goods change the stochastic process governing consumption. For asset pricing this is potentially important.

The goal of this paper is to address this issue. First, I construct an ideal price index, and show how the new goods bias affects the stochastic discount factor. Incorporating new goods introduces another risk factor into the CCAPM: as well as pricing standard consumption risk, the model now also prices the variety risk associated with bias in the Consumer Price Index (CPI). Now, another determinant of risk is whether the asset's payoff correlates with the introduction of new and better goods? Yet the main contribution of this paper is an attempt to quantify this risk factor, and assess its importance for asset prices.

To do this, I use data on product substitution rates from the Bureau of Labor Statistics (BLS). To determine the evolution of the CPI, the BLS samples a basket of around 80,000 goods each month. Faced with an obsolete product, however, the BLS undertakes a "product substitution" and substitutes a similar product for the old one. Goods exhibiting high substitution rates are typically those that have been replaced with an improved product or a new brand. Using data on substitution rates, I construct a basket of *dynamic* goods: goods exhibiting high substitution rates. Because changes in the consumption of dynamic goods correlate with product improvement and new goods, dynamic goods growth correlates with product variety growth. In other words, it captures another dimension of consumption risk.

I test the two-factor macroeconomic model. In the spirit of Hansen and Singleton (1983), I estimate the stochastic Euler equation by the general method of moments (GMM), and show that the estimation implies a lower degree of risk aversion; that is, the model attenuates the equity premium puzzle. Following this, I use the standard Fama and MacBeth (1973) procedure and show the model can price the 25 Fama-French portfolios almost as well as the benchmark Fama-French three-factor model. Although both risk factors are significant, most of the explanatory power derives from movements in the consumption of the dynamic goods. In contrast to static goods, the dynamic basket is more volatile and correlates more highly with equity returns. Especially for the case of durables, the consumption of dynamic goods more likely covaries with marginal utility and expectations about the future: having purchased commitment goods—such as health insurance and fuel—dynamic goods are more likely to comprise the marginal unit.

This paper contributes to a literature that focusses on measurement issues in consumption. An early contribution is Aït-Sahalia et al. (2004), who maintain that the marginal unit of consumption comprises luxury goods consumed by the rich. Supporting this, they find luxury goods have greater pricing power than aggregate consumption. Exemplifying another approach is Savov (2011), who explores the role of garbage growth as a proxy for consumption growth; according to him, this avoids many of the aggregation issues associated with aggregate consumption. Proceeding along similar lines, Da et al. (2010) explores the role of household production in the CCAPM; Da and Yun (2010) use electricity growth as a proxy for consumption growth; while Chen and Lu (2013) use carbon dioxide omissions. Focussing on the issue of adjustment frictions, Parker and Julliard (2005) use the long-run growth of consumption, while Jagannathan and Wang (2007) uses the fourth-quarter to fourth-quarter consumption growth. Underlying these papers is the use of another measure of consumption or timing convention, which improves the empirical performance of the CCAPM.

While this paper examines the new goods bias in the context of asset pricing, the bias is well recognized in the economics literature. Hausman (2003) argues forcefully that the new goods bias is a first-order issue, and existing adjustments are "severely inadequate." Reflecting high levels of product innovation, Broda and Weinstein (2010) find sixty percent of the products in their sample had been introduced over the preceding four-year period. While the BLS performs hedonic adjustment for certain durable goods, such adjustments are non-existent for most goods. This study shows how the bias has potentially important consequences for consumption-based asset pricing. Recent work in finance, for example, emphasizes how small changes in the stochastic processes for consumption—such as its precise GARCH specification—has large effects on asset prices (Bansal and Yaron, 2004). Incorporating new goods, however, changes the consumption process. Moreover, continuing technological progress will likely accentuate the bias over time.

I proceed as follows. In Section 1, I present a simple model that highlights the implication of CPI bias for asset pricing. Here I define consumption as a CES index a consumption basket incorporating new goods and quality improvements, and derive the Euler equation and expected risk premium. In Section 2, I derive an ideal price index for consumption and compare the index to what the BLS measures—and highlight the source of the CPI bias. Having presented the model, I devote Section 3 to a description of data and presentation of results. In Section 4, I use dynamic goods to perform a calibration to determine more general asset price implications. Following this, Section 5 concludes.

1 The Model

I present a simple model with separable utility and a representative consumer. The consumption basket is

$$c_{jt} \equiv m_t^{v+1-\frac{1}{\alpha}} \left(\int_0^{m_t} (A_t^{\gamma} c_{jit})^{\alpha} \, di \right)^{\frac{1}{\alpha}}, \tag{1}$$

where $c_{jit} \geq 0$, $\alpha \in (0,1)$, and $\mathfrak{m}_t > 0$ denotes the number of brands actually consumed.

A rise in quality A_t increases the utility derived from the consumption of each brand, and $\gamma > 0$ mediates the taste for quality. For clarity, I set the upper integral limit to m_t and not to infinity, but technically utility is defined over the range $[0, \infty)$ of goods. Since there is a continuum of brands, the elasticity of substitution between brands within each group is $\frac{1}{1-\alpha} \in (1, \infty)$.

Following Benassy (1996), $v \in (0, \infty)$ mediates the taste for brand variety, and governs the elasticity of the marginal utility of consumption with respect to the number of brands consumed. This parameter disentangles the distinct concepts of elasticity of substitution between brands—which also equals the elasticity of demand for each brand—and love of variety.[1] As a result, this formulation can handle situations where the consumer might be highly responsive to price changes, but still have a large taste for variety; or cases where the consumer has little taste for variety, but perceives goods as imperfect substitutes. The price of a unit of product group c_{j_t} is

$$p_{j_t} = A_t^{-\gamma} m_t^{-v-1+\frac{1}{\alpha}} \left(\int_0^{m_t} p_{ji_t}^{\frac{\alpha}{\alpha-1}} \, di \right)^{\frac{\alpha-1}{\alpha}} . \tag{2}$$

Taking the stochastic distributions of income, m_t, and A_t as given, the consumer maximizes expected lifetime utility

$$U = \mathbb{E}_0 \sum_{t=0}^{t=\infty} \beta^t \frac{{c_{jt}}^{1-\theta}}{1-\theta}. \tag{3}$$

where $\mathbb{E}_0\{\,\}$ is an expectations operator, conditional on information at time $t = 0$. The subjective rate of time preference is $\rho > 0$, and $\beta \equiv \frac{1}{1+\rho}$. The associated stochastic Euler equation for holding an asset with random nominal return $\tilde{i}_t$ between time t and $t+1$ is

[1] To see why, suppose consumption expenditure on a group is C_t. Given symmetry and strict concavity, people consume all available brands in equal quantities, so $c_{jt} = m_t^{v+1-\frac{1}{\alpha}} m_t^{(\frac{1}{\alpha}-1)} A_t^{\gamma} C_t = m_t^{v} A_t^{\gamma} C_t$. The parameter $v > 0$ now mediates the marginal utility gain to consuming additional brands. By comparison, the standard Dixit and Stiglitz (1977) function conflates the degree of love of variety with the elasticity of substitution and implicitly assumes $v = \frac{1}{\alpha} - 1$.

$$\beta \mathbb{E}_t \left[(1+\tilde{i}_{t+1}) \left(\frac{p_{j_t}}{p_{j_{t+1}}} \right) \left(\frac{u'(c_{j_{t+1}})}{u'(c_{j_t})} \right) \right] = 1, \tag{4}$$

Because of diminishing marginal utility to brands, it is optimal to consume an equal quantity of each. Given prices of unity for each existing good, the quantity demanded of each existing good is then $c_{ji_t} = \frac{C_t}{m_t}$ for all $j \in [0, n_t]$ and $i \in [0, m_t]$, where C corresponds to the total quantity of goods consumed. Ignoring time subscripts the Euler equation is

$$\beta \, \mathbb{E} \left[(1+\tilde{r})(1+\tilde{g}_c)^{-\theta}(1+\tilde{g}_m)^{v(1-\theta)}(1+\tilde{g}_A)^{\gamma(1-\theta)} \right] = 1, \tag{5}$$

where $\tilde{g}_c$ is real expenditure growth. This formulation makes the analysis comparable to the standard CCAPM. Without variety growth, $\tilde{g}_m = \tilde{g}_A = 0$, and this reduces to the standard Euler equation. In that setting, people derive utility from the perfect substitutes c_{ji_t} and ultimately the *quantity* of goods consumed, $C_t = \int_0^{m_t} c_{ji_t} \, di$.

Taking differences and unconditional expectations of the linearized Euler equations for both the risk-free and risky assets gives the expected equity premium:

$$\mathbb{E}\,(r - r_f) = \theta \sigma_{r,g_c} + v(\theta-1)\sigma_{r,g_m} + \gamma(\theta-1)\sigma_{r,g_A}. \tag{6}$$

I refer to this as the *VCCAPM*.

2 Price Indices and Variety Growth

It is useful to compare the *ideal* price index associated with consumption c_{jt}

$$p_{jt} = A_t^{-\gamma} m_t^{-v-1+\frac{1}{\alpha}} \left(\int_0^{m_t} p_{jit}^{\frac{\alpha}{\alpha-1}} \, di \right)^{\frac{\alpha-1}{\alpha}} = A_t^{-\gamma} m_t^{-v} p_{jit} \tag{7}$$

and a price index where $v = \gamma = 0$ that omits the welfare gains to variety and quality growth:

$$p_{jt} = m_t^{-1+\frac{1}{\alpha}} \left(\int_0^{m_t} p_{jit}^{\frac{\alpha}{\alpha-1}} \, di \right)^{\frac{\alpha-1}{\alpha}} = p_{jit}. \tag{8}$$

Calculating the ideal price index (7) above requires measuring the degree of variety growth along with the attendant welfare gains. While in theory the welfare gain to a new good is the difference between its virtual price—the price at which demand is zero—and its actual price, incorporating such calculations into a price index makes any systematic exercise intractable. For this reason, the Bureau of Labor Statistics (BLS) omits the consumer surplus improvement associated with new products; i.e., they assume $v = 0$.[2] Yet as shown by Hausman (1996), this can be significant even for relatively similar goods such as new breakfast cereals. Likewise, Broda and Weinstein (2010) maintain that the net gains to product creation and destruction are largely unaccounted for, and the CPI still contains "substantial bias." Using supermarket data, for example, Melser (2006) finds a new goods bias of between 1.2 and 2.4 percent a year. Although the BLS performs quality adjustment for a limited number of goods—such as computers—Hausman (2003) argues that current procedures are "severely inadequate." For 80 percent of goods comprising consumer durable expenditure over the period 1980-1996, Bils and Klenow (2001a) find the BLS overestimates inflation by 2.2 percent. To summarize, the BLS omits gains to new goods and underestimates quality, making Eq. (8) a better reflection of what the CPI measures.

3 Data and Methodology

In this section, I use the growth of dynamic goods—goods subject to innovation—as a proxy for variety growth. In contrast to trademark data, data on dynamic goods is available at quarterly frequency—making it suitable for analyzing asset price dynamics. Along with consumption, I use this data to test the VCCAPM and determine whether it can explain return variation over time and across both the 25 Fama-French

[2] According to Abraham, Greenlees, and Moulton (1998), the consumer surplus technique "may never be adaptable for implementation in a large, ongoing price measurement program like the CPI."

portfolios and 17 industry portfolios. Following this, I use dynamic goods to approximate a process for variety growth, which I use to simulate the model.

Primarily I am concerned here with the equity premium and time-varying risk, and thus focus on brand and quality growth. Complicating measurement, however, is the difficulty in disentangling brand and quality growth. While in theory these are distinct phenomena, in practice the difference is often unclear; a new brand, for example, could incorporate higher quality. Thus to make the estimation operational, I subsume both into a single variable, which I refer to as "variety growth," $\tilde{g}_{mA_t}$. I impose a taste for variety of $\tilde{v} = .7$, which is an average of the tastes for brands v and quality γ. For the purpose of empirical work, instead of estimating Eq. (5), I estimate

$$\beta\, \mathbb{E}_t \left[(1+\tilde{r}_t)(1+\tilde{g}_{ct})^{-\theta}(1+\tilde{g}_{mA_t})^{.7(1-\theta)} \right] = 1, \tag{9}$$

where g_{mA} denotes variety growth.[3]

3.1 Data and Regressions

I perform the analysis over the period 1951 Q1-2012 Q2. The Bureau of Economic Analysis (BEA) provides quarterly data on consumption components from 1949 onwards, but because of unusually high re-stocking of consumer durables following World War 11, I start the analysis in 1951. Data on consumption expenditure and price deflators are from the National Income and Product Accounts (NIPA), provided by the BEA. I measure the market return by the value-weighted return on the NYSE-AMEX portfolio, from the Center for Research in Security Prices (CRSP). The risk-free return is the return on a three-month Treasury bill, from the CRSP database. Throughout, I deflate all returns by the personal consumption deflator, while I deflate aggregate consumption and its components by their price deflators. Data on the Fama-French portfolio

[3] Because this formulation removes the complementarity between quality and brand growth, it leads to more conservative estimates of the impact of variety on asset prices. In the estimation I also impose a nonstochastic trend in product group growth. This refers to growth in radical innovations such as cars, computers, air travel, and so on. This has no bearing on the risk premia dynamics I focus on in this paper.

returns and industry returns are from Kenneth French's website. Trademark registration data is from the Historical Statistics of the United States. To obtain per capita values, I deflate all quantity series by population data, available from the U.S. Census Bureau. Following Campbell (2002), I use the beginning-of-period time convention in the calculation of growth rates; that is, I assume all reported consumption takes place at the beginning of each period.

Central to the analysis is the measurement of the Consumer Price Index (CPI). Calculating this involves repeatedly sampling the price of the same goods over time; the BLS samples around 72,000 nonhousing goods each month across 40,000 outlets in the U.S. When faced with a discontinued product, however, the Bureau of Labor Statistics (BLS) must substitute a similar product for the old one: this constitutes an "item substitution." Reflecting the importance of these substitutions—and the potential for measurement error—5 percent of goods required substitutions in 1995, but half of CPI inflation arose from these goods (Ekstrand, 1999). Significantly, a high average substitution rate for a product category reflects greater product creation in that category; e.g., while the rate was .4 for tobacco products, it was 9.2 for household appliances in 1997 (Ekstrand, 1999). For this reason, both Bils and Klenow (2001b) and Nakamura and Steinsson (2008) use the substitution rate as a measure of product innovation.

Motivated by this, I use the growth rate of the consumption of *dynamic* goods—those with a high substitution rate—as a proxy for "variety growth." Especially since greater consumption of dynamic goods is often a response to variety growth (Bils and Klenow, 2001b), dynamic goods growth should correlate with variety growth. In contrast to say trademarks, this measure also reflects the actual consumption of new goods. Yet instead of focussing on goods, I focus on substitution rates across product categories. Because there is little variation in item substitution rates within categories, this facilitates a more direct comparison to BEA consumption data.

For the analysis, I use category substitution rates for the period 1998-2005, available from the appendix of Nakamura and Steinsson and shown in Table 7.[4] To determine

[4]Calculating the item substitution rate for a product involves dividing the number of product substi-

which categories are dynamic, I choose a cut-off substitution rate of one, implying dynamic goods comprise approximately 30 percent of consumption. Below this cut-off the categories are mainly services, which tend to be stable in nature over time.[5] The dynamic basket comprises the following categories: transportation goods (e.g., cars), apparel, recreation goods (e.g., consumer electronics), household furnishing, processed foods, and unprocessed food.[6] To determine dynamic goods growth, I then weigh the growth rates of consumption of each component by their respective expenditure shares in the basket: on average the shares are 20 percent for clothing, 25 percent for food, and 50 percent for durables.[7] For expenditure shares, I use a moving average of expenditure shares on each component over the past 4 years; this way, a fall in one component is not double counted as a fall in the share *and* a fall in the growth rate.

Particularly important here is the measurement of the consumption flow from consumer durables (henceforth *durables*). Following other studies, I assume the service flow from durables is proportional to the stock. Yet there are lags to the adjustment of durables, which would be especially relevant in calculating the adjustment to stock returns in quarterly data. Recognizing this, I calculate the growth of the stock over a number of periods. Parker (2001) shows the flow and the stock of durables are cointegrated, and estimates the growth rate of the stock over a number of periods by taking the growth rate of the flow over those periods. Exploiting this insight, I use the six-

tutions by the product's lifetime in the sample. For the categories listed, the substitution rate refers to the expenditure-weighted median monthly frequency of price changes associated with item substitutions in that category.

[5]One exception is travel services. As a result of services related to new vehicles, some goods within this category have high substitution rates; for example, goods comprising "automobile maintenance and repair" had a relatively high substitution rate of 15.5 in 1997. Yet, in the context of the model, these components more closely resemble inputs than final consumption goods. For this reason, I assume travel services represent static goods. Regarding clothing, the replacement of clothing on shelves also captures seasonal changes. Thus the relatively high substitution rate for clothing overestimates new product growth.

[6]Because items in a category typically have similar item substitution rates, a finer disaggregation would produce similar results. Because the CPI and NIPA good categorizations are different, analyzing at a finer level of disaggregation makes it difficult to compare both series.

[7]Reflecting the rising relative cost of services, expenditures as a share of total consumption fall over time. Yet such changes do not imply a falling importance of variety—which in fact rose over this period (Bils and Klenow, 2001b).

quarter growth rate of durable goods expenditure as an estimate of the growth rate of the durables stock over that period. For annual data, I use the two-year growth rate. Most important, these time frames correspond to those yielding the best fits of the CCAPM in Parker. From now on, I refer to this multi-period growth measure as *ultimate* growth.

3.2 Time Series Tests

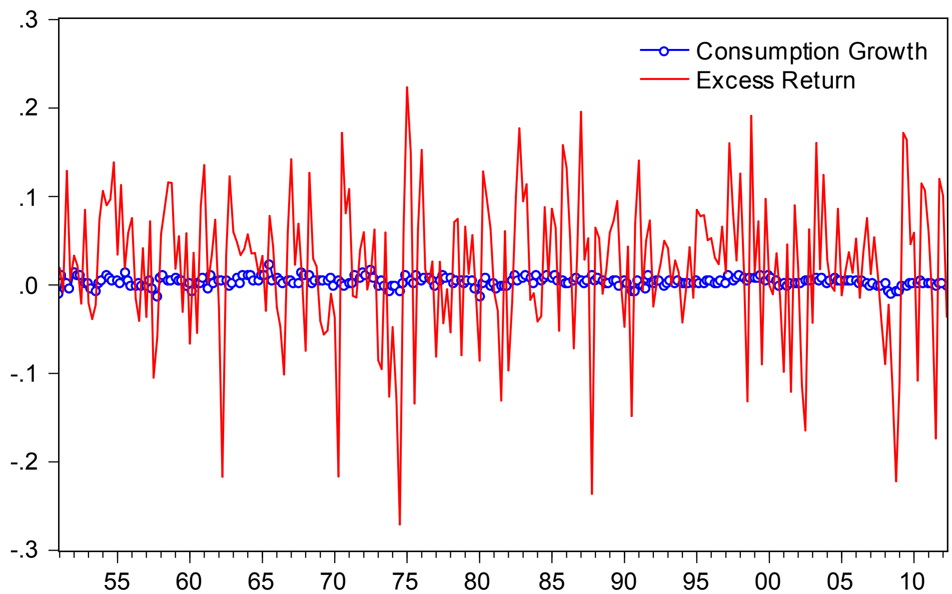


Figure 1: CONSUMPTION GROWTH AND EXCESS RETURNS, 1951Q1-2012Q4. EXCESS RETURNS REFER TO THE REAL EXCESS RETURNS, $\tilde{r}^e$, ON THE CRSP NYSE-AMEX VALUE-WEIGHTED PORTFOLIO OVER 3-MONTH TREASURY BILLS.
Source: CRSP and BEA.

Figure 1 shows the variation in consumption growth and the excess real return on the market index and consumption growth over the period 1951Q1-2012Q4. Figure 2 presents a similar graph with dynamic goods growth. Contrasting with the stability of consumption growth, dynamic goods growth is volatile and covaries over ten times more with returns. As a result, explaining returns should now require a lower degree of risk aversion. To test this, I use the general method of moments (*GMM*) and the Euler

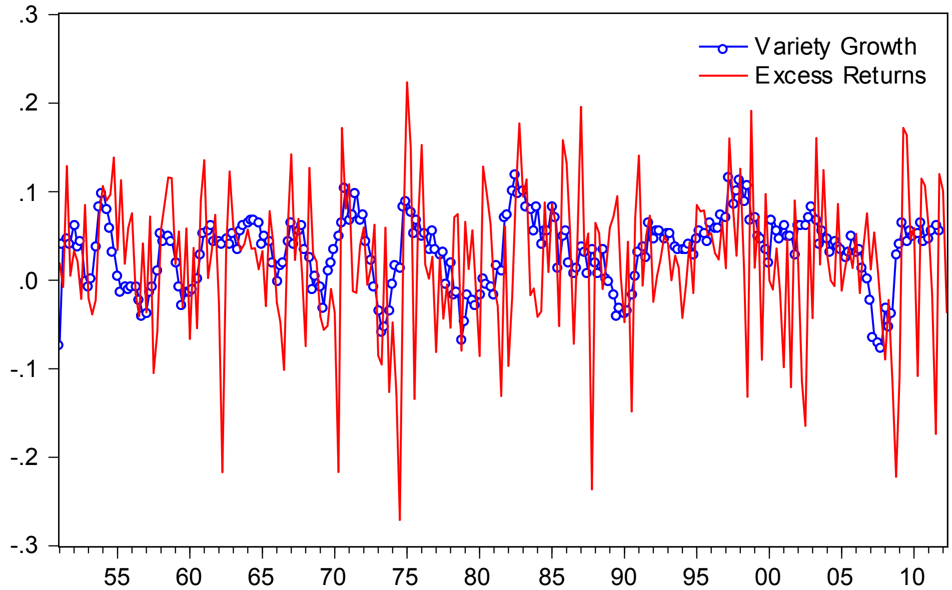


Figure 2: DYNAMIC GOODS GROWTH AND EXCESS RETURNS, 1951Q1-2012Q4. EXCESS RETURNS REFER TO THE REAL EXCESS RETURNS, $\tilde{r}^e$, ON THE CRSP NYSE-AMEX VALUE-WEIGHTED PORTFOLIO OVER 3-MONTH TREASURY BILLS.
Source: CRSP and BEA.

equation, Eq. (9), to estimate the discount factor β and the coefficient of relative risk aversion, θ. Table 1 presents results for quarterly data for the standard VCCAPM, the CCAPM, and models using services growth and ultimate consumption growth—i.e., consumption growth over the ensuing 6 quarters—as proxies for consumption growth. For instruments I use variables known to predict returns: one period lags of i) the default spread on corporate bonds (Baa-AAA); ii) the term spread between the long-term yield on government bonds and Treasury bills; and iii) the book-to-market ratio, the ratio of book-value to market-value for the Dow Jones Industrial Average (DJIA). As result, this amounts to a test of the conditional model in each case: that is, do the movements in returns predicted by these instruments correspond to the predicted movements in variety and consumption?

Compared to the CCAPM, which implies a risk aversion of 9.4, the VCCAPM implies a lower level of risk aversion of 2.1. Movements in variety growth introduce more risk and, by reducing required risk aversion, attenuate the equity premium puzzle. Although the Hansen-J test for overidentification fails to reject the model, the standard errors on risk aversion are large. Table 2 presents results for annual data; here, I include the successful Jagannathan and Wang (2007) fourth-quarter to fourth-quarter measure of consumption growth. For instruments I use one-period lags of i) the default spread on corporate bonds (Baa-AAA); ii) the spread between the long-term yield on government and corporate bonds; and iii) the book-to-market ratio for the DJIA. Similar to the quarterly data results, the risk aversion implied by the VCCAPM falls by a factor of around four. Apparent throughout are the more precisely estimated parameters of the VCCAPM model.

3.3 Cross-Sectional Variation in Returns

Because they exhibit a large spread in returns, I first use the 25 size and book-to-market Fama-French portfolios to test the model. Having a moderate number of observations and a large number of assets, I use the Fama-MacBeth procedure. Given the error-in-variables problem associated with using estimated betas from the first-stage regression, I report results with Shanken (1992) standard errors incorporating a Newey and West (1987) three-lag correction. According to the model, both consumption and variety growth should be significant, with the intercept insignificant. Together with the root mean square error (RMSE), the unadjusted R^2 provides a measure of goodness of fit.

Table 3 summarizes the results for quarterly data over the period 1951Q1-2012Q2. Common to all the regressions is the pricing of variety risk. For the VCCAPM model in Column 1, the intercept is small and insignificant. While variety commands a positive risk premium, consumption is insignificant; one reason for this is collinearity between consumption and variety growth. Column 2 highlights the poor performance of the standard CCAPM. Compared to an R^2 of 66 percent for the VCCAPM model, the value here is only 2 percent. Corresponding to the risk prices in the models are implied measures of risk aversion. From the VCCAPM, I infer risk aversion of 15 associated with variety risk and 12 with consumption.[8] By contrast, the CCAPM implies a risk aversion of 121. Figure 3 shows the fits of four models in quarterly data.

Another way to estimate the growth of the stock of consumer durables—and hence growth in the service flow—is through the perpetual inventory method. Accounting for adjustment lags, I calculate the six-quarter growth rate of the stock, and then use this figure to estimate another measure of variety growth; Column 4 shows the results for this estimation.[9] Although there is a decline in R^2 from 66 to 51 percent, this measure is highly significant. Noting that SMB and HML refer to the Fama-French mimicking portfolios relating to size and book-to-market equity ratios, Column 5 presents results for the classic three-factor Fama and French (1993) model. Compared to the CCAPM, the R^2 value here is a marginally higher 69 percent. Combining variety growth with the Fama-French three-factor model yields a model with an R^2 of 72 and the smallest pricing error.

The model's fit suggests it can explain most of the size and value premia. Holding size constant in the time series regressions, variety betas double in magnitude as the book-to-market ratio rises from lowest to highest. For the size portfolios, the relationship is negative but less pronounced. Reflecting the failure of consumption to explain the size and value premia, there is no coherent pattern to the consumption betas across portfolios. Compared to the CCAPM, the model prices the anomalous small growth and large value portfolios well.[10] A related question is whether the risk factors HML and SMB proxy—or are mimicking portfolios—for variety growth. Figures 4 and 5 show the comovements of the HML and SMB portfolio annual returns with both new trademark growth and variety growth over the period 1951-2012. Of both portfolios, HML moves closest with both measures, exhibiting a 30 percent correlation with variety growth.

[8]Denoting the coefficient of relative risk aversion by θ, the price of consumption risk is $\lambda_c = \frac{\theta Var\, \tilde{g}_c}{1-\theta(\mathbb{E}\tilde{g}_{mA}+\mathbb{E}\tilde{g}_c)}$, while the price of variety risk is $\lambda_{mA} = \frac{\theta Var\, \tilde{g}_{mA}}{1-\theta(\mathbb{E}\tilde{g}_{mA}+\mathbb{E}\tilde{g}_c)}$. The implied value of θ derives from the estimates of λ from the Fama-MacBeth regressions.

[9]According the Yogo (2006), depreciation amounts to 6 percent a quarter or 22 percent a year.

[10]For the VCCAPM, the respective pricing errors are -0.54 and 0.10. For the Fama-French model, the

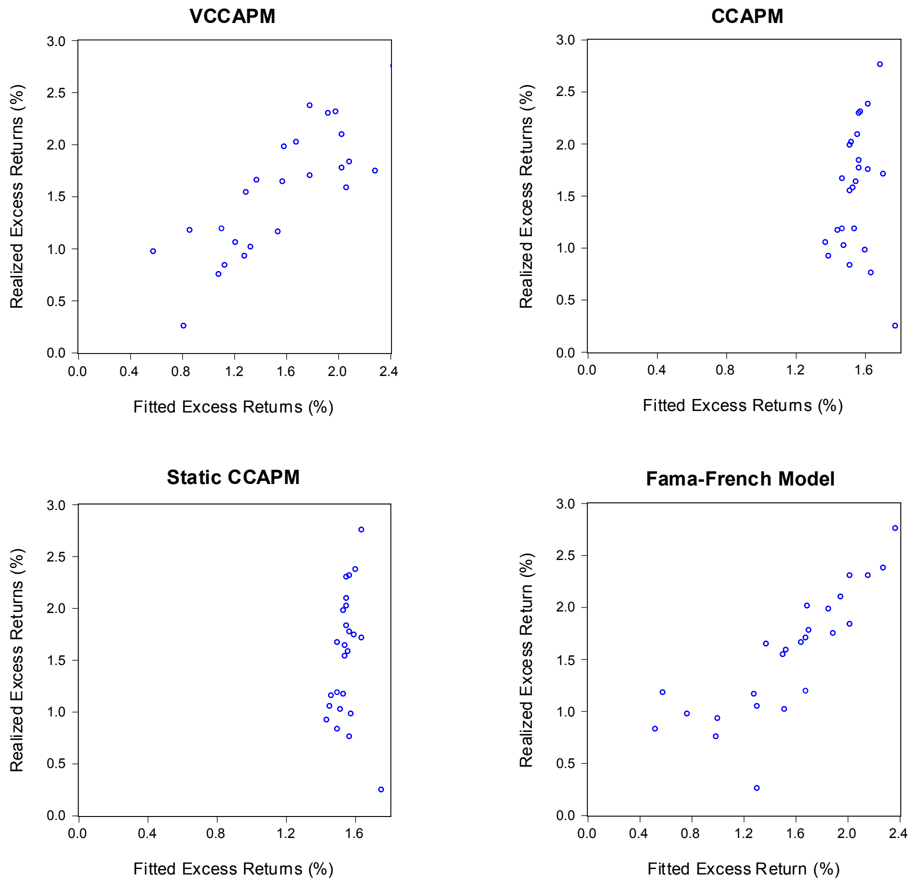


Figure 3: Fitted and Realized Excess Returns: Quarterly Data, 1951Q1-2012Q2. This shows realized versus predicted excess returns for the VCCAPM, the CCAPM, the Static CCAPM (using services as a proxy for consumption), and the Fama-French model. Dots represent quarterly excess returns on 25 Fama-French portfolios sorted by size and book-to-market equity.

Examining dynamic goods further, I decompose the dynamic goods basket into three components—food, clothing, and consumer durables—and test the pricing power of each. Table 4 presents the results. Except for clothing, all components of variety are significant.[11] What underlies the poor performance of the CCAPM is evident in Column 4: although it is the largest component of consumption expenditure, the ser-

errors are -1.03 and -0.48.

[11]Clothing has a durable component which weakens the relationship between consumption and returns in the short run. This could explain the insignificance at a quarterly frequency. By contrast, clothing is significant at the annual frequency—where this issue becomes less pronounced.

vices factor exhibits little pricing power for returns. Although not shown, most service components—apart from transport, recreation, and "other," which together comprise less than a quarter of services—of NIPA consumption have no pricing power for returns. Column 5 uses aggregate consumption—i.e., including durables—as a risk factor. Reinforcing the evidence that durables matter above and beyond their standard consumption flow, this factor is insignificant. For the ultimate consumption measure—the growth in consumption over six quarters—the regression yields an R^2 of 25 percent.

Complementing the findings for quarterly data, Tables 5 and 6 summarize the Fama-MacBeth results for annual data. Comparing columns, the results broadly parallel those for quarterly data. Here, however, both variety and consumption are significant in the VCCAPM. In Column 4, I use trademark stock growth as a proxy for variety growth.[12] Available only at annual frequency, this independent measure of variety is highly significant. Regarding goodness of fit, the VCCAPM model does as well as the Fama-French model: both have an R^2 of 80 percent. Yet the intercept is highly significant for the Fama-French model and its extension incorporating variety. Finally, as stressed by Aït-Sahalia, Parker, and Yogo (2004), the marginal unit of consumption comprises a large luxury component. In a Fama-MacBeth regression of returns on luxury expenditure growth and variety growth in Column 7, variety drives out luxury growth. This suggests the measure of luxury growth in Aït-Sahalia et al. captures the purchase of new high-end products. Similar to Table 4, Table 6 presents results for other measures of consumption. Along with the components, I include fourth-quarter to fourth-quarter consumption growth (Jagannathan and Wang, 2007), and ultimate consumption growth over the following two years.

[12] By definition, trademarks represent the registration of new innovations. Assuming the stock of trademarks is proportional to the stock of goods, the growth rate of the trademark stock equals that of the number of goods. Using the perpetual inventory technique, I estimate the trademark stock from the annual number of trademark registrations and renewals. Because trademark data is only available annually, I use this measure in the annual estimation. Yet there are problems with trademark data. One issue is the possibility of a lag between trademark registration and product release. Additionally, a single firm could issue a number of products under the same trademark, which would be the case for large firms, who introduce most new products (Broda and Weinstein, 2010). Finally, there is no way to quantify how significant a new trademark is.

3.4 Discussion

Throughout, the price of variety risk remains significant. The superior performance of dynamic goods suggest they better reflect variation in marginal utility. On the face of it, this is a natural finding: the marginal unit of consumption likely comprises a new discretionary item—such as a new Ipad. More generally, incorporating variety raises the correlation between returns and a broader measure of consumption, thereby attenuating the "correlation puzzle."

Among the components of variety growth, durable goods exhibit the most volatility and pricing power. By focussing on nondurables and services, the standard CCAPM omits these. In the context of the model, durables incorporate new goods and thus command a risk premium. Yet in addition to this, introspection suggests the purchase of a new good—especially a durable such as a car—initially has an effect above and beyond its imputed service flow: there is a novelty to buying a new product. Supporting this, Da, Yang, and Yun (2010) report residential electricity usage is strongly procyclical. Factoring in this interaction between usage and variety growth and the associated welfare gain would amplify the mechanism outlined here.

A limitation of the analysis is the measurement of variety growth. Because they contain a large proportion of new goods, the consumption of dynamic goods should correlate with the welfare gains to expanding variety and quality. Yet, as with any proxy, one concern is it captures variation in other risk factors. Nonseparability between the components of variety growth and consumption, for example, could also explain the results. While the interaction between durables and nondurables has been explored elsewhere, this study provides another reason for the pricing of durables growth: consumer durables incorporate new goods—such as cell phones—and are among the most salient consumer purchases.[13] Regressing variety on durables gives the component of variety orthogonal to durables, and, as shown in Tables 4 and 6, this residual explains

[13] Previous research emphasizes a role for durables in asset pricing. Yang (2011) analyzes the interaction of durables and long-run risk, and finds it can explain many asset pricing phenomena. In Yogo's model, durables and nondurables are substitutes in utility, and the fall in durable consumption in recessions causes a sharper rise in the marginal utility of consumption.

50 percent of return variation in annual data and 30 percent in quarterly. As such, the variety measure captures more than durables.

3.5 Variety Growth and Industry Returns

Because the extent of product creation differs across industries, comparing industry returns with variety growth provides a natural way to test the model. One prominent example is the retail industry. Coincident with greater variety growth is a rise in consumer demand, benefitting this sector and suggesting its returns and variety growth move together.[14] Examining average returns for different industries over the period 1930-2012, Table 8 confirms the retail sector indeed commands higher average returns. According to Broda and Weinstein (2010), variety growth is strongly correlated across industries and with the business cycle. To test the model it is therefore important to determine which industries have returns that correlate with economy-wide variety growth.

In theory, the relationship between an industry's variety growth and returns is unclear. On the one hand, in times of high variety growth, firms' sales and returns could rise. Representing greater variety risk, the most innovative industries should then command higher returns. On the other hand, a single firm could release a popular product—e.g., Ford introducing a safer car—that takes business from competing firms in the industry. Depending on the degree of competition in the industry, returns could then underperform as variety rises. According to the model, expected returns in the industry would now be relatively low.

Whether industry variety growth and returns move together is therefore an empirical matter. Analyzing new product announcements from 1987-1995, Chen, Ho, and Ik (2005) find that the equity value gains of an innovating firm exceed the fall in returns amongst competitors over a two-day announcement period. This implies a positive relationship between variety growth and returns. Consistent with this is the positive

[14] Broda and Weinstein (2010) report a strong correlation between sales growth and variety growth.

relationship between variety growth and market returns at an aggregate level. To examine this further, I analyse the Fama-French 17 industry portfolios and identify those consumption-oriented industries with high substitution rates. Table 8 shows the annual average returns for these industries and the remaining ones over the period 1930-2012. The high substitution industries have higher average returns, and the difference in means is statistically significant. At the firm level, Chaney, Devinney, and Winer (1991) report higher average returns of firms who introduce new products.

Another issue bearing on this relationship is the degree of complementarity across industries. Greater durable consumption, for example, leads to a rise in electricity usage (Da et al., 2010). An inherent feature of economic activity, such complementarity weakens the relationship between industry variety growth and returns. One way to address this is to estimate variety betas—which account for interactions across industries—and examine their relationship with returns. Therefore, I test the VC-CAPM model using the 17 Fama-French industry portfolios.[15] As shown in Table 9, the relationship is weak. An issue here, however, is the degree of product innovation in industries changes over time, making betas unstable. Bils and Klenow (2001b) analyze variety growth over the period 1959-1999, and report higher variety growth in certain industries over the period 1979-1999. The more pronounced differentials in variety growth over this latter period would sharpen the identification of the model. Consistent with a role for variety in explaining returns, the model has an R^2 of 38 percent over this period, but only 9 percent over the earlier period.

Further cross-sectional evidence comes indirectly from examining durability. Directly related to an industry's substitution rate is the degree of durability of its output. According to Table 7, as this increases, the substitution rate also rises.[16] As a result, a comparison of durability and returns provides an indirect way to determine

[15]While returns for larger sets of industries—up to 49—are available on Kenneth French's website, the classifications invariably become more arbitrary as the number of industries rises. Concentrating on the more standard test using seventeen industries, where sectoral designations are more clear-cut, avoids this issue.

[16]As already noted, clothing is an exception. Because of seasonal introductions, the high substitution rate overestimates the degree of product innovation.

the relationship between variety growth and returns. Using NAICS input-output tables to isolate each firms' contribution to output—thereby controlling for spillovers across industries—Gomes, Kogan, and Yogo (2009) sort firms into three sectors: consumer durables, nondurables, and services. They find a strong positive relationship between the degree of durability and average returns. According to them, a given change in the desired stock requires a larger change in the flow, making durables demand more volatile. This study provides another microfoundation for their results: the more durable the output, the greater the variety risk.

4 Calibration with Dynamic Goods Series

To evaluate the model's ability to explain variation in risk premia, I simulate it at quarterly frequency over 25,000 periods and annualize results. To isolate the role of the variety channel, I model consumption growth as a random walk with drift:

$$g_{c_t} = \mu + e_t.$$

For variety growth, I use the time series developed in Section 3. This reveals a positive relationship between variety and consumption growth. Incorporating this dependence and permitting the possibility of time-varying risk, I follow Lochstoer (2009) and model variety growth as a general GARCH-in-mean process. Empirically, variety growth evolves as

$$g_{mA_t} = .0428 - 3.677\sigma_{g_{mA_t}} + 1.433 g_{c_t} + \sqrt{\sigma_{g_{mA_t}}}\epsilon_t, \tag{10}$$

where ϵ_t is an *i.i.d.* $N(0,1)$ variable and

$$\sigma_{g_{mA_t}} = .000181 + .9\,\sigma_{g_{mA_{t-1}}}\epsilon_{t-1}^2 + .08\,\sigma_{g_{mA_{t-2}}}\epsilon_{t-2}^2.$$

The negative relationship between the level of variety growth and its variance makes this a conditional asset pricing model. For reasons outlined in Section **??**, I assume group growth follows a constant positive trend, and set its growth rate in Eq. **??** to match the historical average risk-free rate of 2 percent. I model dividend growth as the sum of a constant, consumption growth, and a shock term. I choose the constant to match the average dividend growth of .74 and the variance of the shock to match dividend growth volatility. The correlation between dividend and variety growth is .3, which I infer from annual data on dividends and variety growth. The correlation between consumption and variety growth is .4. I choose shock correlations to match these figures.

Table 10 displays the simulation results for the VCCAPM for various degrees of love of variety and risk aversion. The baseline model in Column 4 with $\tilde{v} = .7$ generates an equity premium of 1.3 percent and provides a partial solution to the equity premium puzzle. By comparison, the CCAPM produces a negligible premium of .2 percent. The persistence of heteroskedasticity in a recession causes a rise in the expected equity premium and, in turn, equity return volatility. Yet this time-varying risk premium is small: of the 13 percent standard deviation in the baseline VCCAPM model, 11.3 percent arises from dividend growth and the rest from time-varying risk. Notably, a combination of risk aversion of 10 and love of variety of one matches the equity premium and its volatility.

In contrast to the CCAPM, the risk-free rate is procyclical. Given the GARCH-in-mean component, high and stable variety growth occur together. This reduces precautionary savings and raises the incentive to borrow. Both effects cause the risk-free rate to rise and the price-dividend ratio to fall. Countering this is the higher price-dividend ratio induced by a lower expected equity premium. Combining effects, the price-dividend ratio ultimately falls marginally in a boom. Yet the internal dynamics of the model are weak: the persistence and volatility of the price-dividend ratio is relatively low and insufficient to generate significant time-variation in returns.[17] One

[17]In unreported work, I regress excess equity returns on the dividend yield over various horizons—spanning one to 5 years. Reflecting the stability of the price-dividend ratio, there is little predictability

reason is the measure of variety growth is crude and differs from the true process. Another reason is the model is missing some feature—such as time-varying risk aversion that would raise the price-dividend ratio in a boom. Including for example habit persistence at the level of goods as in Ravn et al. (2007) would redress this.

5 Conclusion

Three facts motivate this paper: i) all assets are claims to future goods; ii) the variety of those goods changes over time; and iii) new goods confer welfare gains. Recognizing these facts, this paper extends the CCAPM, and shows how expanding product variety affects asset prices. Over the business cycle, fluctuating brand and quality growth increases the level of consumption risk and raises the expected equity premium. Consistent with the theory, the model performs well empirically: it explains most of the variation in the 25 Fama-French size and book-to-market portfolio and predicts a relatively low level of risk aversion in time series data. To mitigate measurement issues, the paper considers multiple parameter values and stochastic processes for variety growth. For benchmark parameters, the simulations imply an equity premium of around 1.5-2 percent. Yet for a risk aversion of 10 and relatively high degree of love of variety, the model can match the equity premium and risk-free rate. Overall, by taking a broader view of consumption, the framework thus highlights another dimension of consumption risk, and complements existing consumption-based models.

of returns at any horizon.

References

Abraham, K. G., J. S. Greenlees, and B. R. Moulton (1998). Working to improve the Consumer Price Index. *Journal of Economic Perspectives 12*(1), 27–36.

Aït-Sahalia, Y., J. A. Parker, and M. Yogo (2004). Luxury goods and the equity premium. *Journal of Finance 59*(6), 2959–3004.

Bansal, R. and A. Yaron (2004, 08). Risks for the long run: a potential resolution of asset pricing puzzles. *Journal of Finance 59*(4), 1481–1509.

Benassy, J.-P. (1996). Taste for variety and optimum production patterns in monopolistic competition. *Economics Letters 52*(1), 41–47.

Bils, M. and P. J. Klenow (2001a). Quantifying quality growth. *American Economic Review 91*(4), 1006–1030.

Bils, M. and P. J. Klenow (2001b). The acceleration of variety growth. *American Economic Review 91*(2), 274–280.

Broda, C. and D. E. Weinstein (2010). Product creation and destruction: evidence and price implications. *American Economic Review 100*(3), 691–723.

Campbell, J. Y. (2002). Consumption-based asset pricing. Harvard Institute of Economic Research Working Papers 1974, Harvard - Institute of Economic Research.

Chaney, P. K., T. M. Devinney, and R. S. Winer (1991). The impact of new product introductions on the market value of firms. *The Journal of Business 64*(4), 573–610.

Chen, S.-S., K. W. Ho, and K. H. Ik (2005). The wealth effect of new product introductions on industry rivals. *The Journal of Business 78*(3), 969–996.

Chen, Z. and A. Lu (2013). Carbox dioxide omissions and asset pricing. Working Papers 11310, Kellog School of Management.

Da, Z., W. Yang, and H. Yun (2010). Household production and asset prices. Working Papers 11310, Mendoza College of Business.

Da, Z. and H. Yun (2010). Electricity consumption and asset prices. Working Papers 11310, Mendoza College of Business.

Dixit, A. K. and J. E. Stiglitz (1977). Monopolistic competition and optimum product diversity. *American Economic Review 67*(3), 297–308.

Ekstrand, L. E. (1999). Consumer price index: impact of commodity analysts' decision-making needs to be assessed. Congressional Requesters 15504, United States General Accounting Office.

Fama, E. F. and K. R. French (1993). Common risk factors in the returns on stocks and bonds. *Journal of Financial Economics 33*(1), 3–56.

Fama, E. F. and J. D. MacBeth (1973). Risk, return, and equilibrium: empirical tests. *Journal of Political Economy 81*(3), 607–36.

Gomes, J. F., L. Kogan, and M. Yogo (2009). Durability of Output and Expected Stock Returns. *Journal of Political Economy 117*(5), 941 – 986.

Hansen, L. P. and K. J. Singleton (1983). Stochastic consumption, risk aversion, and the temporal behavior of asset returns. *Journal of Political Economy 91*(2), 249–65.

Hausman, J. (2003). Sources of bias and solutions to bias in the consumer price index. *Journal of Economic Perspectives 17*(1), 23–44.

Hausman, J. A. (1996). Valuation of new goods under perfect and imperfect competition. In *The Economics of New Goods*, NBER Chapters, pp. 207–248. National Bureau of Economic Research, Inc.

Jagannathan, R. and Y. Wang (2007). Lazy investors, discretionary consumption, and the cross-section of stock returns. *Journal of Finance 62*(4), 1623–1661.

Lochstoer, L. A. (2009). Expected returns and the business cycle: heterogeneous goods and time-varying risk aversion. *Review of Financial Studies 22*(12), 5251–5294.

Melser, D. (2006). Accounting for the effects of new and disappearing goods using scanner data. *Review of Income and Wealth 52*(4), 547–568.

Nakamura, E. and J. Steinsson (2008). Five facts about prices: a reevaluation of menu cost models. *The Quarterly Journal of Economics 123*(4), 1415–1464.

Newey, W. K. and K. D. West (1987). A simple, positive semi-definite, heteroskedasticity and autocorrelation consistent covariance matrix. *Econometrica 55*(3), 703–08.

Parker, J. A. (2001). The consumption risk of the stock market. *Brookings Papers on Economic Activity 32*(2), 279–348.

Parker, J. A. and C. Julliard (2005). Consumption risk and the cross-section of expected returns. *Journal of Political Economy 113*(1), 185–222.

Ravn, M. O., S. Schmitt-Groh, and M. Uribe (2007). Pricing to habits and the law of one price. *American Economic Review 97*(2), 232–238.

Savov, A. (2011). Asset pricing with garbage. *Journal of Finance 66*(1), 177–201.

Shanken, J. (1992). On the estimation of beta-pricing models. *Review of Financial Studies 5*(1), 1–33.

Yang, W. (2011). Long-run risk in durable consumption. *Journal of Financial Economics 102*(1), 45–61.

Yogo, M. (2006). A consumption-based explanation of expected stock returns. *Journal of Finance 61*(2), 539–580.

Table 1: **GMM Estimation of Euler Equation at Quarterly Frequency**

Model	VCCAPM	CCAPM	Serv.	ULT.
β	0.99	1.01	.99	1.06
	(0.02)	(0.03)	(0.02)	(0.08)
θ	2.06	9.42	7.04	1.34
	(0.49)	(4.35)	(4.34)	(0.94)
Observations	243	245	245	239
Hansen J	0.69	0.36	0.18	0.53

Using quarterly data from 1951-2012, this table reports the two-stage GMM estimates—with optimal weighting matrix—of various consumption-based models. Based on the discussion in Section **??**, I assume mean quarterly group growth is 0.003%, implying a taste for groups of $\zeta = 12$. I estimate β and θ from the Euler equation

$$\beta\, \mathbb{E}_t \left[(1+\tilde{r^e}_{t+1})(1+\tilde{g}_{c_{t+1}})^{-\theta}(1+\tilde{g}_{mA_{t+1}})^{\tilde{v}(1-\theta)}(1+.003)^{12} \otimes z\right] = 1,$$

where $\tilde{g}_{mA}$ denotes variety growth and z the instruments. *VCCAPM* is the model with $\tilde{v} = .7$ and $\tilde{g}_c$ the growth of nondurables and services consumption. *CCAPM* is the model with $\tilde{v} = 0$ and $\tilde{g}_c$ the growth of nondurables and services consumption. *Serv.* is the model where $\tilde{v} = 0$ and $\tilde{g}_c$ the growth of services consumption. *ULT.* is the model where $\tilde{v} = 0$ and $\tilde{g}_c$ the subsequent six-quarter growth rate of consumption (Parker, 2001). Returns refer to the real excess returns, $\tilde{r^e}$, on the CRSP NYSE-AMEX value-weighted portfolio over 3-month Treasury bills. For instruments, z, I use one-period lags of i.) the default spread on corporate bonds (Baa-AAA); ii.) the term spread between the long-term yield on government bonds and 3-month Treasury bills; and iii.) the ratio of book-value to market-value for the Dow Jones Industrial Average. Standard errors are in parentheses.

Table 2: **GMM Estimation of Euler Equation at Annual Frequency**

Model	VCCAPM	CCAPM	Serv.	JW	ULT.
β	0.96	1.12	0.94	0.91	1.16
	(0.07)	(0.20)	(0.11)	(0.05)	(0.19)
θ	2.54	8.58	5.71	3.88	5.00
	(0.91)	(5.17)	(4.77)	(2.47)	(2.47)
Observations	60	60	60	60	60
Hansen J	0.49	0.44	0.32	0.47	0.79

Using annual data from 1951-2012, this table reports the two-stage GMM estimates—with optimal weighting matrix—of various consumption-based models. Based on the discussion in Section **??**, I assume mean annual group growth is 1.2%, implying a taste for groups of $\zeta = 12$. I estimate β and θ from the Euler equation

$$\beta\, \mathbb{E}_t \left[(1+\tilde{r^e}_{t+1})(1+\tilde{g}_{c_{t+1}})^{-\theta}(1+\tilde{g}_{mA_{t+1}})^{\tilde{v}(1-\theta)}(1+.012)^{12}\otimes z\right] = 1,$$

where $\tilde{g}_{mA_{t+1}}$ denotes variety growth and z the instruments. *VCCAPM* is the model with $\tilde{v} = .7$ and $\tilde{g}_c$ the growth of nondurables and services consumption. *CCAPM* is the model with $\tilde{v} = 0$ and $\tilde{g}_c$ the growth of nondurables and services consumption. *Serv.* is the model where $\tilde{v} = 0$ and $\tilde{g}_c$ the growth of services consumption. *JW* refers to the model with $\tilde{v} = 0$ and $\tilde{g}_c$ the fourth-quarter to fourth-quarter growth of consumption (Jagannathan and Wang, 2007). *ULT.* refers to the model where $\tilde{v} = 0$ and $\tilde{g}_c$ the subsequent two-year growth rate of consumption (Parker, 2001). Returns refer to the real excess returns, $\tilde{r^e}$, on the CRSP NYSE-AMEX value-weighted portfolio over 3-month Treasury bills. For instruments I use one-period lags of i) the default spread on corporate bonds (Baa-AAA); ii) the spread between the long-term yield on government and corporate bonds; and iii) the ratio of book-value to market-value for the Dow Jones Industrial Average. Standard errors are in parentheses.

Table 3: **Fama-MacBeth Quarterly Regressions**

Model	(1) VCCAPM	(2) CCAPM	(3) Dyn.	(4) DynPIT	(5) F-F	(6) F-F-V
Consum.	0.06	0.95		0.04		
	(0.30)	(3.96)		(1.72)		
Dyn.	5.72		5.15	2.10		2.41
	(3.83)		(5.25)	(3.26)		(1.66)
HML					1.41	1.51
					(5.87)	(5.61)
SMB					0.46	0.57
					(1.98)	(4.96)
MKT.					-0.33	0.54
					(-0.32)	(0.33)
Intercept	-1.00	1.15	-1.61	1.16	1.43	0.58
	(0.99)	(0.97)	(2.62)	(0.77)	(1.14)	(0.40)
R^2	0.66	0.02	0.56	0.51	0.69	0.72
RMSE	0.34	0.59	0.40	0.41	0.33	0.31

This table reports the output from Fama-MacBeth regressions for various models over the period 1951Q1-2012Q2. The test assets are the 25 Fama-French portfolios sorted by size and book-to-market ratio at quarterly frequency. Returns refer to excess returns on these portfolios over 3-month Treasury bills. The left-hand column lists the risk factors. *Consum.* refers to nondurables and services consumption growth; *Dyn* refers to dynamic goods growth; *MKT.* refers to the market portfolio return: the value-weighted return on the NYSE-AMEX portfolio, from the Center for Research in Security Prices (CRSP). The top row identifies the consumption-based model. *DynPIT* refers to the model using the perpetual inventory technique to estimate the stock of durables. *F-F-V* refers to the Fama-French model with variety as an additional risk factor. The first 5 rows report the factor risk premia estimated from a cross-sectional regression of average returns on estimated betas. The betas are the coefficients on the risk factors in time series regressions of returns on those factors. The sixth row reports the intercept. I report Shanken standard errors with a three-lag Newey and West (1987) correction for autocorrelation and heteroskedasticity. T-values are in parentheses.

Table 4: **Quarterly Regressions: Different Consumption Measures**

	(1) Food	(2) Cloth.	(3) Durables	(4) Serv.	(5) AgCons.	(6) ULT.	(7) Orthog.	(8) LUX.
Consum.	0.89	0.05	13.38	0.08	0.34	2.63	1.04	-4.80
	(1.89)	(0.08)	(4.29)	(0.28)	(0.86)	(2.18)	(4.10)	(-1.12)
Intercept	-0.20	1.46	-1.72	1.24	0.32	-0.72	0.40	3.00
	(0.22)	(1.21)	(2.21)	(1.12)	(0.02)	(-0.73)	(1.27)	(11.85)
R^2	0.18	0.00	0.55	0.01	0.08	0.25	0.30	0.09
RMSE	0.53	0.57	0.40	0.59	0.57	0.51	0.49	0.60

This table reports results from Fama-MacBeth regressions for the period $1951Q1 - 2012Q2$ for components of the variety basket—food, clothing, and durables—together with other consumption–related risk factors. The test assets are the 25 Fama-French portfolios sorted by size and book-to-market ratio at quarterly frequency. Returns refer to excess returns on these portfolios over 3-month Treasury bills. The top row identifies the consumption growth measure. *Serv.* refers to the growth of services consumption; *AgCons.* refers to total consumption growth, including durables; *ULT.* refers to ultimate consumption growth—the growth of consumption over the following six quarters. *Orthog.* refers to the component of variety growth orthogonal to durables growth. *LUX.* refers to luxury goods expenditure growth; data is available from Motohiro Yogo's website for the period 1961-2001. The first row reports the factor risk premia estimated from a cross-sectional regression of average returns on estimated betas. The second row reports the intercept. I report Shanken standard errors with a three-lag Newey and West (1987) correction for autocorrelation and heteroskedasticity. T-values are in parentheses.

Table 5: **Fama-MacBeth Annual Regressions**

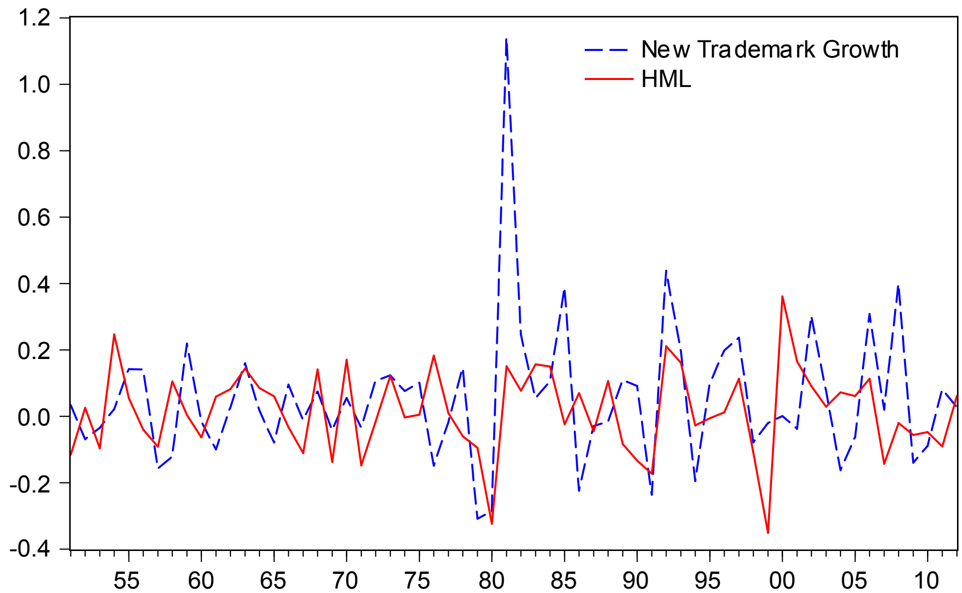
Factor	(1) VCCAPM	(2) CCAPM	(3) DynPIT.	(4) TMARK	(5) F-F	(6) F-F-V	(7) LUX.	(8) LUX.-V
Consum.	0.58	0.77	0.83	1.07				
	(2.98)	(1.21)	(2.00)	(6.08)				
Dyn.	5.32		2.64	1.93		2.79		8.0
	(14.09)		(10.27)	(5.33)		(2.33)		(14.60)
Lux.							14.0	4.0
							(2.32)	(1.59)
HML					5.04	5.23		
					(5.87)	(7.07)		
SMB					2.12	2.19		
					(1.98)	(3.95)		
MKT.					-3.39	-2.33		
					(-1.24)	(-0.79)		
Intercept	0.64	0.59	3.78	-2.78	7.30	6.75	-2.60	-8.0
	(0.28)	(0.12)	(0.87)	(-1.17)	(2.84)	(2.15)	(-0.78)	(-7.88)
R^2	0.80	0.16	0.64	0.75	0.80	0.84	0.18	0.79
$RMSE$	0.33	1.39	0.60	1.28	1.12	1.04	2.78	1.40

This table reports the cross-sectional Fama-MacBeth regressions for various consumption-based models over the period 1951-2012. The test assets are the 25 Fama-French portfolios sorted by size and book-to-market ratio at annual frequency. Returns refer to excess returns on these portfolios over 3-month Treasury bills. The left-hand column lists the risk factors. *Consum.* refers to nondurables and services consumption growth; *Dyn.* refers to dynamic goods growth; *Lux.* refers to luxury goods expenditure growth; *MKT.* refers to the market portfolio return: the value-weighted return on the NYSE-AMEX portfolio, from the Center for Research in Security Prices (CRSP). The top row identifies the consumption-based model. *DynPIT.* refers to the model which uses the perpetual inventory technique to measure the stock of durables. *TMARK* refers to the model where trademark growth proxies for variety growth. *F-F-V* adds variety growth to the Fama-French. *LUX.* refers to the model with luxury goods expenditure growth as a risk factor. Luxury expenditure data is from the period 1961-2001 and is available from Motohiro Yogo's website. The first six rows report the factor risk premia estimated from a cross-sectional regression of average returns on estimated betas. The seventh row reports the intercept. I report Shanken standard errors with a three-lag Newey and West (1987) correction for autocorrelation and heteroskedasticity.

Table 6: **Annual Regressions: Different Consumption Measures**

	(1) Food	(2) Cloth	(3) Dur.	(4) Serv.	(5) AgCons.	(6) JW	(7) ULT.	(8) Orthog.
Consum.	1.16	1.21	11.85	0.61	1.23	2.63	3.64	5.00
	(1.19)	(1.30)	(10.47)	(0.86)	(2.35)	(5.78)	(6.50)	(8.04)
Intercept	0.08	2.25	-1.16	3.09	-1.39	-3.58	-1.02	-2.00
	(0.02)	(0.71)	(-1.79)	(0.79)	(0.36)	(1.75)	(-0.70)	(1.28)
R^2	0.22	0.14	0.72	0.10	0.35	0.63	0.56	0.50
RMSE	2.27	2.39	1.36	0.24	0.21	0.16	0.17	1.83

This table reports the cross-sectional Fama-MacBeth regressions for components of the variety basket—food, clothing, and durables—together with other consumption-related measures for the period 1951-2012. The test assets are the 25 Fama-French portfolios sorted by size and book-to-market ratio. Returns refer to excess returns on the portfolios over 3-month Treasury bills. The top row identifies the relevant measure of consumption growth. *Serv.* refers to services consumption growth. *AgCons.* refers to total consumption, including durables. *JW* refers to the Jagannathan and Wang (2007) fourth-quarter to fourth-quarter consumption measure. *ULT.* refers to the model with ultimate consumption—the growth of consumption over the following two years. *Orthog.* refers to the component of variety growth orthogonal to durables growth. The first row reports the factor risk premia estimated from a cross-sectional regression of average returns on estimated betas. The second row reports the intercept. I report Shanken standard errors with a three-lag Newey and West (1987) correction for autocorrelation and heteroskedasticity. T-values are in parentheses.



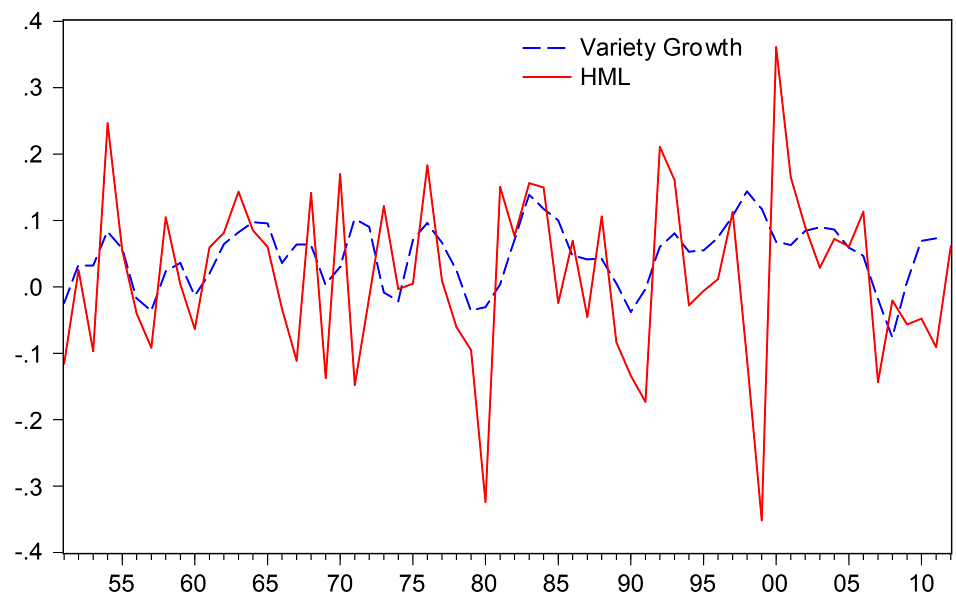
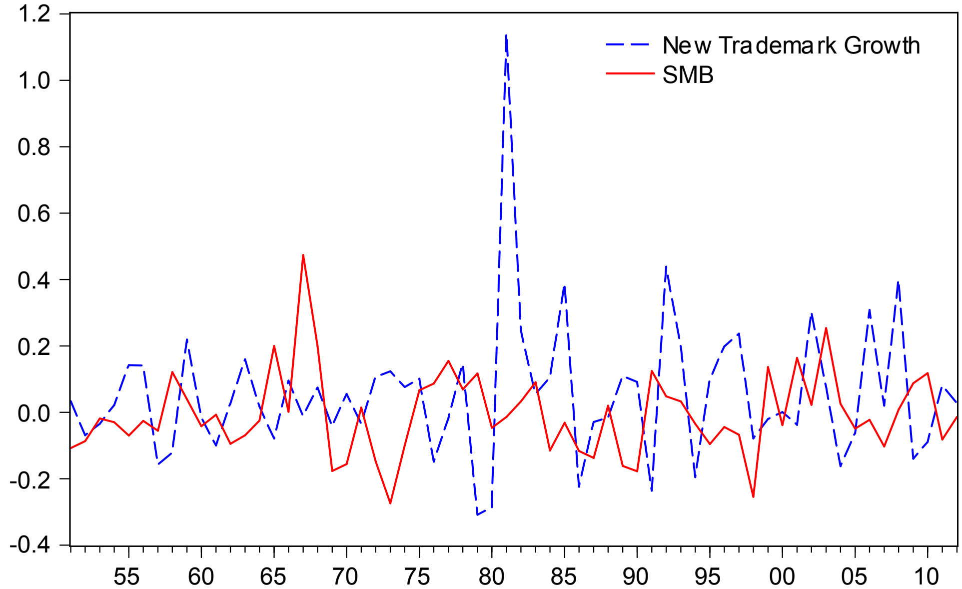


Figure 4: Measures of Variety Growth and Annual Returns on HML Portfolio: 1951-2012



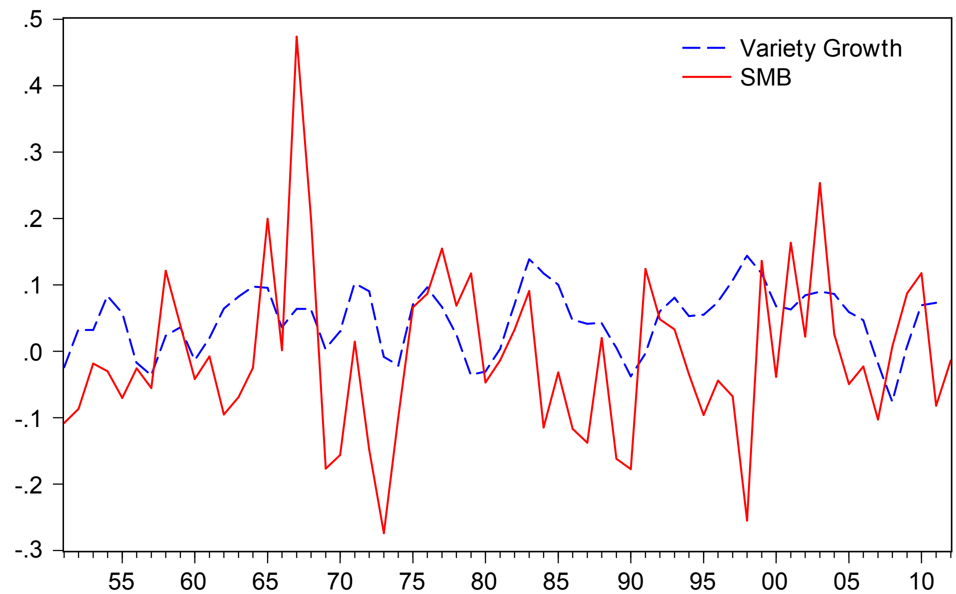


Figure 5: Measures of Variety Growth and Annual Returns on SMB Portfolio: 1951-2012

Table 7: **Substitution Rates and CPI Weights for Different Industries, 1998-2005**

This table is from Nakamura and Steinsson (2008) and presents industry substitution rates together with the corresponding weights in the CPI. In Section 3, I describe how substitution rates are calculated.

Item	Substitution Rate	CPI Weight
Vehicle Fuel	0.2	5.1
Utilities	0.6	5.3
Services (excl. Travel)	0.9	38.5
Other goods	1.0	5.4
Unprocessed Food	1.2	5.9
Processed Food	1.3	8.2
Travel	1.9	5.5
Household Furnishing	5.0	5.9
Recreation Goods	6.3	3.6
Apparel	9.9	6.5
Transportation Goods	10.2	8.3

Table 8: **Average Returns Across Fama-French 17 Industry Portfolios, 1930-2012**

The table reports average annual returns over the period 1930-2012 for the Fama-French 17 industry portfolios. The left-hand column reports returns for consumption-oriented sectors with high product introduction rates or those exposed to variety risk. The level of innovation is inferred from substitution rates. The category "consumables" comprises drugs, perfume, tobacco, and soap.

High Inv. Sector	Return	Low Inv. Sector	Return
Food	6.0	Mines	5.7
Clothing	6.4	Oil	7.0
Consumer Durables	5.8	Chemicals	5.8
Cars	8.4	Consumables	6.3
Retail	6.3	Construction	5.9
		Steel	4.6
		Fabricated Products	4.5
		Machinery	6.2
		Transport	5.1
		Utilities	3.6
		Financial	5.5
		Other	4.3
Average	6.6		5.4

Table 9: **Test of VCCAPM Using Industry Portfolios, 1951-2012**

Column 1 presents the output from Fama-MacBeth regressions of the excess returns on 17 industry returns on variety and consumption growth in quarterly data over the period 1951Q1-2012Q2. *Dyn.* refers to variety growth and *Cons.* to non-durables and services consumption growth. Columns 2 and 3 show the results of the same regression over the periods 1959 Q1-1978 Q4 and 1979 Q1-1999 Q4, respectively. The latter period was marked by relatively high variety growth in certain sectors(Bils and Klenow, 2001b). T-statistics are in parenthesis.

	(1)	(2)	(3)
Period	1951-2012	1959 Q1 1978 Q4	1979 Q1-1999 Q4
Intercept	1.28	-0.37	0.91
	(4.10)	(-0.67)	(1.62)
Dyn.	0.03	0.29	1.59
	(0.08)	(0.81)	(3.33)
Cons.	-0.05	0.06	0.08
	(-0.73)	(0.74)	(0.76)
R^2	0.07	0.09	0.38
RMSE	0.24	0.40	0.52

Table 10: **Simulation Results**

This table presents simulation results for combinations of love of variety, $\tilde{v}$, and risk aversion θ. The discount factor is .99. Unless otherwise stated, risk aversion is $\theta = 5$. Column 4 presents results for the benchmark VCCAPM.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Parameter	Data	CCAPM	$\tilde{v} = .4$	$\tilde{v} = .7$	$\tilde{v} = 1$	$\theta = 10$	$\theta = 10, \tilde{v} = 1$
$\mathbb{E}\ (r - r_f)$	5.93	0.20	0.80	1.32	1.86	3.83	6.63
$\sigma(r - r_f)$	16.83	11.32	12.25	13.03	16.04	18.38	17.71
r_f	2.12	11.61	2.00*	2.00*	2.00*	2.00*	2.00*
$\sigma(r_f)$	1.35	0.00	0.80	1.51	2.31	4.14	6.76
$exp(p - d)$	27.28	36.20	31.32	27.67	25.09	18.79	12.93
$\sigma(exp(p - d)$	1.52	0.0	0.03	0.04	0.04	0.03	0.03
$AC1(exp(p - d)$	0.87	0.21	0.21	0.21	0.21	0.21	0.21

*I choose the rate of group growth to match these figures.